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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of

Walter DEMUTH et al.

Corres. to PCT/EP2004/010158

For: HEAT EXCHANGER IN PARTICULAR FOR MOTOR VEHICLES

VERIFICATION OF TRANSLATION

Commissioner for Patents
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Sir:

I, Susan ANTHONY BA, ACIS,

Director of RWS Group Ltd, of Europa House, Marsham Way, Gerrards Cross, Buckinghamshire, England declare:

That the translator responsible for the attached translation is familiar with both the German and the English language, and that, to the best of RWS Group Ltd knowledge and belief, the attached English translation of International Application No. PCT/EP2004/010158 is a true, faithful and exact translation of the corresponding German language paper.

I further declare that all the statements made in this declaration of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful, false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful, false statements may jeopardize the validity of legal decisions of any nature based on them.

April 11, 2006

Date

Name: S. ANTHONY
For and on behalf of RWS Group Ltd

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Heat exchanger, in particular for motor vehicles

The invention relates to a heat exchanger, in particular for motor vehicles, having a heat exchanger block through which a first medium can flow on the primary side, and around which a second medium can flow on the secondary side.

Such a heat exchanger is described in DE 102 60 030 A1. The heat exchanger in said document is composed, inter alia, of flat pipes with flow ducts, for example extruded multi-chamber pipes, through which a first medium, preferably a refrigerant, in particular CO_2 flows. The flat pipes are arranged parallel to one another and have flat pipe ends which are secured in what are referred to as end pieces, composed of a base plate, a diverter plate and a cover plate. The end pieces each form a distributor unit or diverter unit for the refrigerant. The refrigerant is fed in via a collector pipe which is connected to an end piece - the refrigerant is discharged in an analogous fashion via a further collector pipe which is attached either to the same end piece or to the end piece located opposite. This design provides a particularly pressuretight heat exchanger which can be used in particular for use in a refrigerant circuit, operated with CO_2 for a motor vehicle air conditioning system, specifically both as a vaporizer and as a gas cooler, ambient air being respectively supplied on the secondary side.

In contrast with this, the object of the present invention is to extend the application possibilities of such a heat exchanger.

This object is achieved by means of the features of patent claim 1. According to the invention, a heat exchanger block, composed of pipes and at least one end piece, is surrounded by a housing casing through which

a second medium can be conducted. As a result, further possibilities of use for the heat exchanger according to the invention, in particular in a heat pumping process with the refrigerant CO_2, are obtained using the heat exchanger block which is described in DE 102 60 030 A1, for example, whose content is herewith expressly incorporated in the contents of the disclosure, and a housing casing which is relatively easy to manufacture. Consumption-optimized engines supply too little heat energy so that these vehicles require an additional heater, referred to as a supplementary heater. The coolant for the coolant circuit of the engine is used here as a heat source. The heat exchanger according to the invention can be used in this heat pump circuit both as a CO_2 vaporizer, which absorbs heat from the coolant, and as a CO_2 gas cooler which transfers heat to the coolant. The housing casing which can be manufactured as a sheet-metal component permits many variation possibilities for the guidance of the flow of the coolant so that a parallel flow, counter flow, cross flow as well as parallel/counter-cross flow is possible. As a result, it is possible to make allowance for the various requirements made of the heat exchangers according to the invention.

Further refinements of the invention are specified in the subclaims.

According to advantageous refinements of the invention, the inlet and the outlet for the second medium can be arranged on the same side, on opposite sides and at opposite ends of the housing casing, there being in particular a flow through the housing casing in the longitudinal direction. This results in the possibility of the parallel flow and the counter flow of the first and second media.

According to one advantageous development of the invention, distributor and collector chambers are formed in the housing casing in the region of the inlet and outlet so that the second medium is distributed uniformly over the individual gaps between the pipes and/or collected at the outlet.

According to a further refinement of the invention, what are referred to as turbulence inserts or corrugated ribs are arranged between the pipes and form longitudinal ducts as well as a guide in the longitudinal direction of the pipes for the second medium. These turbulence inserts preferably extend only between the inlet and the outlet of the second medium so that in each case an inflow region and an outflow region are left in the vicinity of the inlet and outlet and there can be a cross flow of the second medium, i.e. transverse with respect to the longitudinal direction of the pipes, in said regions.

According to a further advantageous refinement of the invention, the second medium can also flow across the pipes in the transverse direction, specifically in a single flow or multiple flow. This can be done by arranging lateral collector boxes and dividing walls in conjunction with diversion boxes in the housing casing. The turbulence inserts and the ribbing between the pipes is then configured in such a way that transverse ducts for guiding the second medium are produced. This ensures that both media for example a refrigerant and a coolant, can be guided in the cross-parallel flow or cross-counter flow modes. This produces a more intensive exchange of heat.

In a further advantageous refinement of the invention, there can either by a single flow or a dual flow of the first medium through the pipes, the inlet and outlet chambers for the first medium being arranged either at

an end piece or at various end pieces. As a result, a wide variety of shapes and combinations of parallel flow, counter flow and cross flow between the first and second media can be implemented with the heat exchanger according to the invention depending on the requirements made of the heat exchanger, for example in a refrigerant circuit and in a coolant circuit of an internal combustion engine of a motor vehicle.

Exemplary embodiments of the invention are illustrated in the drawing and will be explained in more detail below. In the drawing:

fig. 1	shows a refrigerant/coolant heat exchanger with a housing casing,
fig. 1a	shows the heat exchanger according to fig. 1 without a housing casing,
fig. 1b	shows the heat exchanger according to fig. 1a in an exploded illustration,
fig. 1c	shows a schematic illustration of the refrigerant circuitry,
fig. 2	shows a heat exchanger with obliquely indented ribbing and diversion of the refrigerant (dual flow),
fig. 2a	shows the heat exchanger according to fig. 2 but without diversion of the refrigerant (single flow),
fig. 3	shows a heat exchanger with ribbing which is indented at right angles and with dual flow of the refrigerant,
fig. 3a	shows the heat exchanger according to fig. 3 but with single flow of the refrigerant,
fig. 4	shows a heat exchanger with dual flow of the coolant in the longitudinal direction,

fig. 5 shows a cross section through a heat exchanger with a view of the end sides of the flat pipes,

fig. 6 shows a longitudinal section through a flat pipe with end pieces,

fig. 7 shows a further exemplary embodiment of a heat exchanger with transversely directed coolant, and

fig. 8 shows a further exemplary embodiment of a heat exchanger with transversely directed coolant flow which is diverted twice.

Fig. 1 shows a refrigerant/coolant heat exchanger 1, i.e. a heat exchanger, through which a refrigerant flows, for example CO_2 (R744) on the primary side and a coolant flows on the secondary side, said coolant serving at the same time to cool an internal combustion engine (not illustrated) of a motor vehicle. As a result, the coolant circuit of the internal combustion engine and the refrigerant circuit of the air conditioning system of a vehicle have a heat-exchanging connection to one another via this heat exchanger. The refrigerant circuit can be used as a heat source for additionally heating the passenger compartment when said circuit is operated in the heat pumping process. In this context, heat is extracted from the coolant in the vaporizer, "pumped" to a relatively high temperature level and returned to the coolant as input heat in the gas cooler. The heated coolant then outputs this heat to ambient air via a heating element (not illustrated), said air being fed as warm air to the passenger compartment of the vehicle. In this respect, this heat exchanger 1 can be used both as a vaporizer and as a gas cooler in the CO_2 heat pumping process. The CO_2 process is known to take place under high pressure compared to the conventional refrigerant process with R134a; for example compression to

approximately 120 bar takes place, said compression thus occurring in the gas cooler. For this reason, the heat exchanger must be dimensioned and constructed in a particularly pressuretight fashion with respect to the conduction of the refrigerant.

The heat exchanger 1 has a housing casing 2 which is embodied approximately in the form of a box and has four longitudinal sides 2a-2d, the longitudinal sides 2a and 2b of which can be seen in the drawing. The housing casing 2 is closed off at the ends by end pieces, only the end piece 3 of which can be seen in the drawing. The refrigerant inlet pipe 4 and a refrigerant outlet pipe 5 are attached to this end piece 3. A coolant inlet connector 6 (only partially visible) and a coolant outlet connector 7 are arranged on opposite sides of the housing casing 2. As already mentioned, the heat exchanger 1 is connected at one end to a refrigerant circuit, in particular a CO_2 circuit (not illustrated) and at the other end to a coolant circuit (not illustrated) of an internal combustion engine of a motor vehicle.

Fig. 1a shows the heat exchanger 1 according to fig. 1 without a housing casing 2, identical reference numerals being used for identical parts. An end piece 8, which is connected to the end piece 3 by a plurality of flat pipes 9, is located opposite the end piece 3 to which the refrigerant collector pipes 4, 5 are attached. A corrugated piece of sheet metal 10 with longitudinal ducts 10a which extend in the longitudinal direction of the flat pipes 9 is arranged on the top flat pipe 9.1. The profile of the corrugated piece of sheet metal can, as illustrated in the drawing, be of trapezoidal design but can also have other forms, for example a sinusoidal or triangular section. The corrugated piece of sheet metal 10 does not extend over the entire length of the flat pipes 9 from the left-

hand end piece 3 as far as the right-hand end piece 8 but rather has in each case an oblique indented edge 10b, 10c at the ends. Corrugated pieces of sheet metal 10 are (not visible in this illustration) each arranged between adjacent flat pipes 9 so that in these regions the coolant is guided longitudinally. Likewise, the corrugated pieces of sheet metal can also be provided with slots and/or offsets so that exchange is possible between the longitudinal guiding ducts for the coolant so that more homogenous distribution and/or turbulences of the coolant and ultimately an increased transfer of heat are possible. Pieces of sheet metal with transversely extending coolant ducts can also be used to make the surface larger and thus increase the efficiency of the heat exchanger.

In the regions which remain free owing to the oblique indents 10b, 10c, transverse flow of the coolant is possible. The refrigerant (which is explained in more detail below) flows from the inlet pipe 4 via the end piece 3, which acts as a distributor unit, to the flat pipes 9 as far as the second end piece 8 which act as a diverter unit, and back to the outlet pipe 5 through the flat pipes 9. This refrigerant unit is referred to as a heat transfer block 11 or as block 11 for short.

Fig. 1b shows the heat exchanger block 11 in an exploded view. Here too, identical reference numerals are used again for identical parts. It is to be noted that a number of possibilities for the guidance of the flow of refrigerant are described in DE 102 60 030 A1, to be precise both in the embodiment illustrated here as well as in further embodiments and modifications. DE 102 60 030 A1 is thus incorporated in its entire extent into the disclosure contents of this application.

Block 11 is composed of a plurality of flat pipes 9 which are arranged parallel to one another and have flat pipe ends 9a, 9b which are each attached in a base plate 12, 13 and sealed. In each case distributor or diverter plates 14, 15 are arranged above the base plates 12, 13 and are each covered by a closure plate 16, 17. Refrigerant inlet openings 16a and refrigerant outlet openings 16b are arranged in series with the refrigerant inlet pipe 4 and the refrigerant outlet pipe 5 in the front cover plate 16. The base plate 12, diverter plate 14 and cover plate 16 thus form the end piece 3, while the end piece 8 is composed of the base plate 13, the diverter plate 15 and the cover plate 17. As stated in the application which predates the priority date of this document, the design of the end pieces 3, 8 can also be modified, for example the base and diverter plates or diverter and cover plates can each be integrated to form one plate. The same applies to the guidance of the refrigerant, i.e. by means of a modified form of the distributor or diverter plates 14, 15.

Fig. 1c is a schematic illustration of the refrigerant circuitry, i.e. the guidance of the flow of refrigerant according to fig. 1b. For details, reference should be made to the application whose priority date predates this application and which, as stated above, has been incorporated entirely into the subject matter of this application. The refrigerant which enters via the refrigerant inlet pipe 4 and is distributed via the inlet openings 16a passes into the flat pipes 9, i.e. their right-hand section 18, is diverted in the direction of the arrow 19 in the diverter unit or the end piece 8 by means of the diverter plate 15 and then passes back to the base plate 12 in the adjacent flat pipe, in its right-hand section 20, and is guided in the direction of the arrow 21 by means of the diverter plate 14 on the left-hand section 22. As a result, the

refrigerant passes back to the end piece 8 where it is diverted upwards by means of the diverter plate 15 in the direction of the arrow 23 in order to flow back again in the section 24. The refrigerant leaves the block 11 via the diverter plate 14, the refrigerant outlet opening 16b and the refrigerant outlet pipe 5. The refrigerant outlet opening 16b are larger than the refrigerant inlet openings 16a because this block 11 is configured as a vaporizer (with an increasing specific volume); in a gas cooler there would be a different configuration, for example with identical inlet and outlet openings. The refrigerant circuitry described above therefore respectively applies for two flat pipes lying one next to the other.

As already mentioned and stated in the application whose priority date predates that of this document, other refrigerant circuitry variants are possible.

Fig. 2 shows a refrigerant/coolant heat exchanger 25 in ~~longitudinal section, which corresponds~~ to the heat exchanger 1 in fig. 1; identical reference numerals being used for identical parts. The housing casing 2 surrounds the entire block 11 composed of flat pipes 9 and end pieces 3, 8, the housing casing 2 having, in the region of the end pieces 3, 8, a shoulder which is adjoined in each case by a widened region 26, 27 which surrounds the end pieces 3, 8 at the circumference and is sealed with respect to them, for example by soldering. The coolant inlet connecter 6 and the coolant outlet connector 7 are arranged on opposite sides 2a, 2c of the housing casing 2 and each lead into the housing casing 2 via a distributor chamber 28 or a collector chamber 29. This ensures that the coolant is distributed over the entire width. The sectional illustration shows the flat pipes 9 from their longitudinal or lateral side and thus also the corrugated piece of sheet metal 10 with longitudinal

ducts 10a. The corrugated piece of sheet metal 10 has, as already mentioned, oblique indented edges 10b, 10c resulting in inflow and outflow regions 30, 31 in which the transverse flow of the coolant from the inlet connector 6 and in the direction of the outlet connector 7 is possible. Such inflow regions 30 and outflow regions 31 are each located between adjacent flat pipes 9. The coolant is diverted approximately at a right angle directly downstream of the inflow region 30 and flows through the heat exchanger 25 in the longitudinal direction, characterized by the arrow P. The refrigerant flows through the heat exchanger 25, as described above with respect to figs 1b and 1c. The refrigerant and coolant are thus essentially guided in a parallel flow mode and counter flow mode (apart from the diversions).

Fig. 2a shows a variant 32 of the heat exchanger 25 from fig. 2: the guidance of the refrigerant is changed to such an extent that the refrigerant inlet pipe 4′ is located at the end piece 3′ and the refrigerant outlet pipe 5′ is located at the end piece 8′. This means that the refrigerant essentially has a single flow, i.e. is guided in a direction through the heat exchanger 32, while the coolant is guided in the opposite direction, corresponding to the arrow P. The refrigerant can however also be guided in a three flow, five flow or multiple flow (uneven numbered) configuration through the heat exchanger. This results essentially in a counter flow between the refrigerant and coolant.

Fig. 3 shows a further exemplary embodiment of a heat exchanger 33 in which a corrugated piece of sheet metal 34 which is cut to size at right angles is provided with a longitudinal duct 34a. The coolant inlet connecter 6 and the coolant outlet connector 7 are arranged on the same side 2a of the housing casing. An approximately right-angled inflow region 35 is produced

in the region of the inlet connector 6 between the end piece 8 and corrugated piece of sheet metal 34, and a corresponding outflow region 36 is produced in the region of the outlet connecter 7. Here too, a cross flow of the coolant is therefore possible, while otherwise there is a flow through the heat exchanger 33 in the longitudinal direction corresponding to the arrow P. The regions 34 and 36 can also be provided with corrugated pieces of sheet metal or other turbulence generators. The guidance of the refrigerant flow corresponds to that in fig. 2, i.e. the refrigerant inlet pipe 4 and refrigerant outlet pipe 5 are arranged on the same end piece 3.

Fig. 3a shows a variant 37 of the heat exchanger 33 according to fig. 3. The only difference with respect to the heat exchanger 33 is the guidance of the refrigerant which corresponds to that in fig. 2a, i.e. the refrigerant inlet pipe 4′ is attached to the end piece 3′, and the refrigerant outlet pipe 5′ is attached to the end piece 8′. This produces essentially a counter flow between the refrigerant and coolant which flows in the longitudinal direction corresponding to the arrow P.

Fig. 4 shows a further exemplary embodiment of a heat exchanger 38 in which the guidance of the refrigerant is analogous to the exemplary embodiments in figs 2 and 3, i.e. a block 11 according to fig. 1b is used. The coolant inlet connector 6 and the coolant outlet connecter 7 are located directly opposite one another at the same level, i.e. they are both arranged in the region of the end piece 3. A dividing wall 39, which delimits an inflow region 40 on the side of the inlet connector 6 and an outflow region 41 on the side of the outlet connector 7 is arranged centrally between the inlet connector 6 and outlet connector 7. The dividing wall 39 is arranged in each case between adjacent flat

pipes. A corrugated piece of sheet metal 42 with longitudinal ducts 42a adjoins the dividing wall 39 and extends as far as a diverter region 43. The corrugated piece of sheet metal 42 has, as stated above, an approximately trapezoidal section which is soldered in each case to the adjacent flat pipes. As a result, discrete longitudinal ducts 42a are formed, i.e. a cross flow between the longitudinal ducts 42a is not possible. The coolant thus flows out of the inflow region 40 firstly in the upper half of the heat exchanger 38, following the arrow P1, into the diverter region 43 where it is diverted by 180°, i.e. in the opposite direction, corresponding to the arrow P2. It then flows in the lower half of the heat exchanger 38, following the arrow P3, and back into the outflow region 41 and leaves the heat exchanger 38 there via the outlet connector 7.

The coolant thus travels through twice the distance in the heat exchanger 38 compared to the previous exemplary embodiments so that an intensive exchange of heat with the refrigerant takes place. Likewise, a four flow or multiple (even numbered) flow through the heat exchanger by the refrigerant is possible.

Here too, the corrugated pieces of sheet metal are provided with slots and/or offsets so that exchange is possible between the longitudinal guiding ducts for the coolant, and thus more homogenous distribution and/or turbulences of the coolant and ultimately an increased transfer of heat are possible. Pieces of sheet metal with transversely extending coolant ducts can also be used here to make the surface larger and thus increase the efficiency of the heat exchanger.

Fig. 5 shows a cross section through a heat exchanger 44 which corresponds to the heat exchanger in fig. 2, the end piece 3 being omitted. The view here is

therefore directly onto the end sides of the flat pipes 9, which are embodied as extruded multichamber pipes with circular flow ducts 43. In each case a corrugated piece of sheet metal 10 with a trapezoidal section is arranged between adjacent flat pipes 9 and soldered to the flat pipes 9. As a result, discrete longitudinal ducts 10a are formed for the coolant. These pieces of sheet metal can also be provided with slots and/or offsets in order to permit exchange between the longitudinal ducts for the coolant and thus permit more homogenous distribution and/or turbulences of the coolant.

If there is no provision for the coolant to be diverted, as illustrated in fig. 4, but only a single flow is provided, no discrete longitudinal ducts 10a are necessary and instead a transverse connection may be desired between the individual longitudinal ducts. This can be implemented by what are referred to as turbulence baffles (not illustrated) in which the trapezoidal section is arranged in a respectively offset fashion downstream of specific longitudinal sections so that new leading edges and thus increased eddying is produced. The housing casing 2 is embodied here as a U-shaped frame with a shoulder and a widened portion 26 into which the end piece (not illustrated) is inserted. The heat exchanger block 11 (cf. figs 1a, 1b) can thus be easily inserted into the housing 2 and closed off by a lid (not illustrated). The distributor chamber 28 which adjoins the inlet connector 6 extends over the entire height of the housing wall 2c, and in an analogous fashion the collector chamber 29 has approximately the height of the side wall 2a on the side of the outlet connector 7. As a result, the coolant can be distributed between all flat pipes 9, and likewise the coolant can be collected in the collector chamber 29 on the outlet side.

Fig. 6 shows a longitudinal section through a flat pipe 9 which is held with its flat pipe end 9a in the end piece 3 and its flat pipe end 9b in the end piece 8. The two end pieces 3, 8 are embodied as illustrated in fig. 1b. This design for the flat pipes 9 with the end pieces 3, 8 made of individual plates is particularly suitable for high pressures such as occur in the CO_2 refrigerant process.

Fig. 7 shows a further exemplary embodiment of a heat exchanger 46 with a modified coolant guiding means. A refrigerant block 47 is in principle of similar design to the block 11 according to fig. 1b, i.e. it has a first end piece 48 with a refrigerant inlet pipe 49 and refrigerant outlet pipe 50 as well as a second end piece 51 in which the refrigerant is diverted. The end piece 48 has a laterally lengthened base plate 52 to which a coolant inlet duct 53 is attached. The end piece 51 also has a lengthened base plate 54 to which a coolant outlet duct 55 is attached. A housing casing 56 surrounds the block 47 and forms in each case a coolant inlet chamber 57 and a coolant outlet chamber 58, which are each embodied in the form of a wedge. The coolant enters the inlet chamber 57 through the inlet duct 53 and passes from there between the gaps between the flat pipes of the block 47, flows through them in the transverse direction corresponding to the arrows P4, passes into the outlet chamber 58 and from there into the coolant outlet duct 55. This design permits a single transverse flow through the block 47. In order to increase the transfer of heat it is possible (not illustrated here) for corrugated pieces of sheet metal or turbulence inserts to be arranged in turn between the individual flat pipes, said corrugated pieces of sheet metal or turbulence inserts causing the coolant to be guided in the direction of the arrow P4 and generate turbulence.

Fig. 8 shows a further exemplary embodiment of a heat exchanger 59 with a coolant flow which is also guided transversely but is only illustrated schematically. This is shown by means of a longitudinal section through a flat pipe 9, as illustrated in fig. 6. A refrigerant block 60 is divided into three flow regions I, II, III by two dividing walls 61, 62. The regions I, II are connected to one another by a diverter chamber 63, and the regions II, III are connected to one another on the opposite side by a further diverter chamber 64. The coolant enters the region I of the block 60 via an inlet connector 65 (also illustrated only schematically), is diverted in the diverter chamber 63 and then flows through the region II into the diverter chamber 64, is diverted there once more and finally passes into the region III which it leaves via an outlet connector 66. The inlet and outlet connectors 55, 56 and diverter chambers 63, 64 are part of a housing casing (not illustrated in more detail) which surrounds the block 60. This flow guidance, corresponding to the arrows P5, P6, P7, causes the coolant to be guided transversely across the block 60 three times, thus producing a cross flow between the refrigerant and coolant. Of course, only a single diversion with one dividing wall and one diverter box as well as triple diversion or multiple diversion of the coolant are also possible.

The exemplary embodiments of refrigerant/coolant heat exchangers described above are preferably soldered, which applies in particular to the block through which CO_2 flows. In contrast, because of the considerably lower pressure of the coolant, the housing casing could also be connected to the block or its end pieces using alternative connection techniques, for example by bonding or by means of rubber seals. At the same time, other materials such as, for example, plastic, are also possible for the housing casing.

The invention has been explained using the example of a refrigerant/coolant heat exchanger but it also includes other heat exchangers. For example, oil and/or air could flow through a heat exchanger according to the invention and exchange heat with one another or with other media.